The DNA of data changes

A deep dive into redo logs changes and CDC mechanics

Agenda

- Introduction
- Where is the problem?
- Oracle Database phenomenons
- Supplemental Logging as solution
  - Redo log - how it designed?
  - Briefly about the investigation method
  - Row and index (for IOT) operations
  - LOBs
    - Binary XML
- The impact of supplemental logging: how to reduce it
- Q & A

Introduction: Speaker

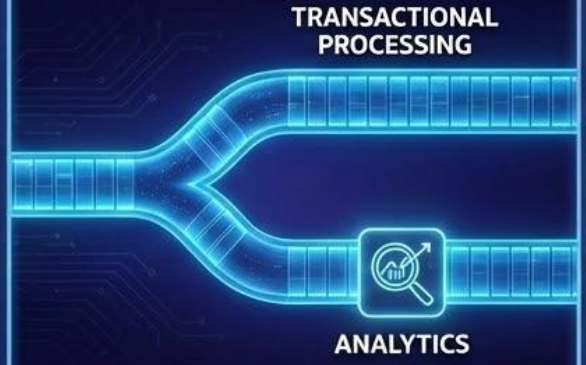
- I have been working with Oracle database since 1993
- 19 years at Oracle Corporation
  - Oracle E-Business Suite Technology
  - Oracle EMEA Treasury Practice
- From 1999 to the present day I have been working with the Treasury of Kazakhstan
  - Greatest non-RAC on-prem OEBS
  - Initially - as Oracle Consultant and Architect
  - Now - as independent Contractor
- 2017 - Apache Kafka

WHERE IS THE PROBLEM?

LGWR AS MAIN TRANSACTIONAL BOTTLENECK

- Unlike DBWn only one per instance. DBWn waits for LGWR write.

BETTER TO DECOUPLE ANALYTICS FROM TRANSACTIONAL PROCESSING



- Reduced TCO and license base.
- CDC as solution.
- Parsing redo even with LogMiner requires Supplemental logging.
- Supplemental logging affects overall performance.

'SCIENTIA POTENTIA EST'

We need knowledge to correctly assess the additional load associated with replication.

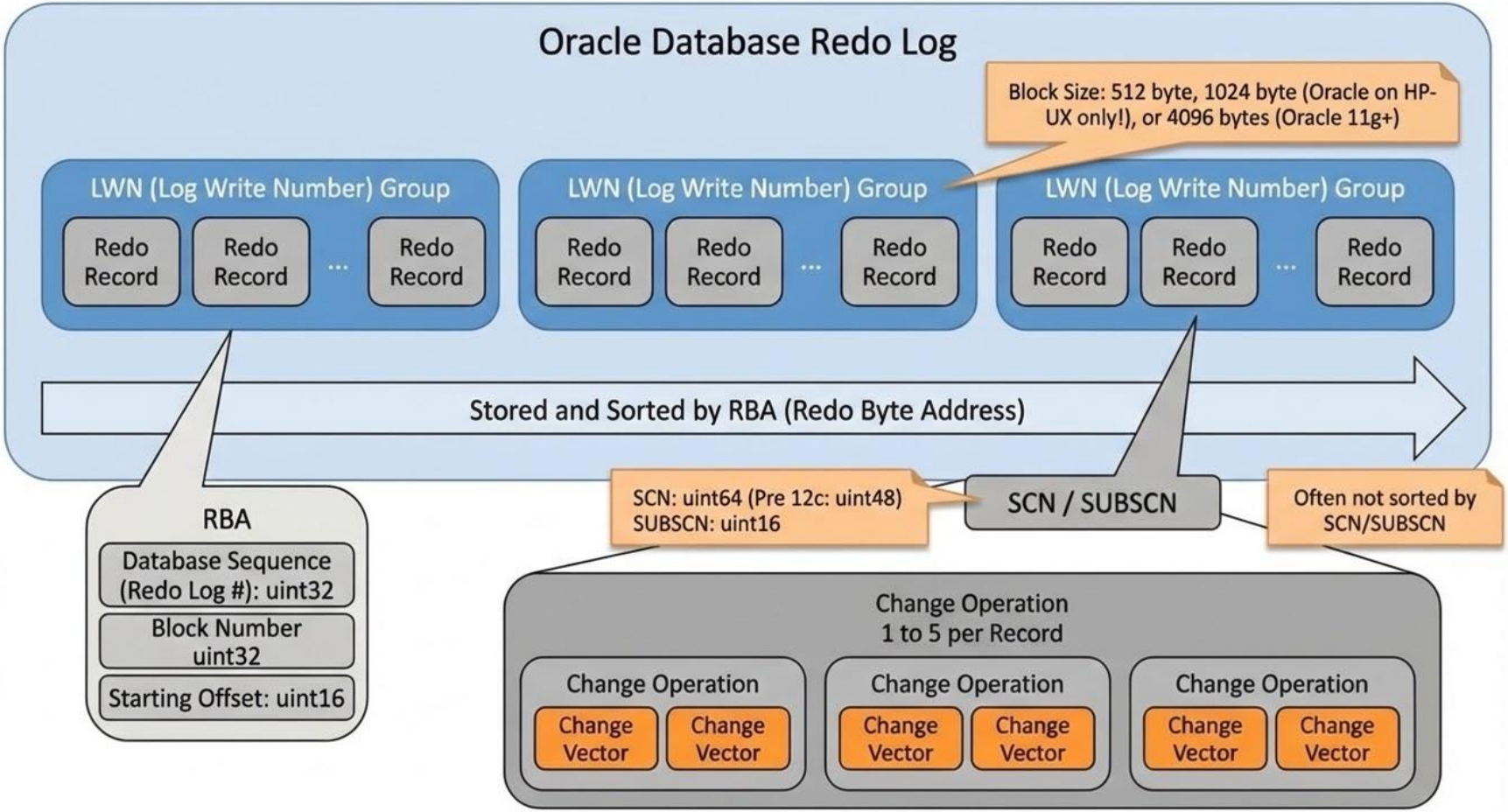
Oracle Database phenomenons

- Transactions
  - COMMIT or ROLLBACK is not necessarily the last command in transaction
    - Always last when sorted by SCN
  - At least two types of implicit ‘BEGIN TRANSACTION’ - OP:5.2 and OP:24.4
- Legacy column count in data/redo block is uint8 -> 255
  - For more columns you need to ‘glue’ changes
    - What about sequence of columns?
    - Row chaining and migration (OP:11.6)
  - there is no direct correspondence between the change vector OP:11.x/OP:10.x and the operation
    - Except single/homogeneous OP:11.5 and OP:11.11 and OP:11.12

Oracle Database phenomenons

- Aliens from planet RDB/CODASYL
  - Large objects
  - Not just
    - BLOB
    - CLOB/NCLOB
    - XMLTYPE
    - JSON
    - VECTOR
  - But there are more LOB’s
    - Extended size RAW/VARCHAR/NVARCHAR
    - UDDT

Redo log - how it designed?



Redo log - how it designed? …contd…

- Change operations
  - OP:19.1 - KCBLCOLB -direct block logging
    - CTAS
  - Row changes - Layer 11. Redo record contains OP:5.1 KTURDB with UNDO/“before” state of row and OP:11.x with REDO/“after” state
  - Index organized tables - similar to heap tables, Layer 10 used instead of Layer 11
  - Large objects - usually OP:26.2 KDLIRREDO paired with OP:5.1 KTURDB and OP:26.6 KDLIRBIMG
  - Partial rollback (ROLLBACK TO SAVEPOINT or just error during execution) OP:5.6/5.11 paired with corresponding Layer 11/Layer 10 operation

Redo log - how it designed? …contd…

- OP:5.1 KTURDB
  - First two elements are ktudb and ktub[l]
    - ktudb contains transaction **`XID`**
    - Ktub[l] contains **`OBJ#`**, **`DATAOBJ#`**, **`OPC`** (indicator of what the data is related to)
  - For row operations i.e. **`OPC=11.1`** the next two elements are KTB Redo and KDO, followed by the column data (if any)
  - For index operations i.e. **`OPC=10.22`** the next two elements are KTB Redo and kdilk
  - For LOB operations i.e. **`OPC=26.1`** the next two elements are KTB Redo and kdli
- Layer 11 (OP:11.x) operations
  - First two elements are KTB Redo and KDO, followed by the column data (if any)
    - OP:11.5 contains column number vector
- Layer 10 (OP:10.x) operations
  - First two elements are KTB Redo and kdilk, followed by the additional data (depends on OP)

```
REDO RECORD - Thread:1 RBA: 0x00000c.00027e41.0010 LEN: 0x0240 VLD: 0x0d CON_UID: 786076231
SCN: 0x00000000002587ae SUBSCN: 1 2026-02-09T11:30:36
(LWN RBA: 0x00000c.00027e41.0010 LEN: 0x00000002 NST: 0x0001 SCN: 0x00000000002587ad)
CHANGE #1 CON_ID:3 TYP:2 CLS:1 AFN:12 DBA:0x03000094 OBJ:74451 SCN:0x000000000025879a SEQ:1 OP:11.5 ENC:0 RBL:0 FLG:0x0000
KTB Redo
op: 0x11  ver: 0x01
compat bit: 4 (post-11) padding: 1
op: F  xid:  0x0007.005.00000327    uba: 0x02408512.0114.1c
Block cleanout record, scn:  0x00000000002587ac ver: 0x01 opt: 0x02 bigscn: Y compact: Y spare: 00000000, entries follow...
  itli: 1  flg: (opt=2 whr=1)  scn:  0x000000000025879a
KDO Op code: URP row dependencies Disabled
  xtype: XA flags: 0x00000000  bdba: 0x03000094  hdba: 0x03000092
itli: 2  ispac: 0  maxfr: 4858
tabn: 0 slot: 0(0x0) flag: 0x2c lock: 2 ckix: 0
ncol: 8 nnew: 2 size: 2
col  5: [ 2]  c2 3d
col  6: [ 2]  c2 33
CHANGE #2 CON_ID:3 TYP:0 CLS:29 AFN:11 DBA:0x024000e0 OBJ:4294967295 SCN:0x0000000000258700 SEQ:1 OP:5.2 ENC:0 RBL:0 FLG:0x0052
ktudh redo: slt: 0x0005 sqn: 0x00000327 flg: 0x0052 siz: 140 fbi: 0
            uba: 0x02408512.0114.1c    pxid:  0x0000.000.00000000        pdbuid:
CHANGE #3 CON_ID:3 TYP:0 CLS:29 AFN:11 DBA:0x024000e0 OBJ:4294967295 SCN:0x00000000002587ae SEQ:1 OP:5.4 ENC:0 RBL:0 FLG:0x0002
ktucm redo: slt: 0x0005 sqn: 0x00000327 srt: 0 sta: 9 flg: 0x2 ktucf redo: uba: 0x02408512.0114.1c ext: 43 spc: 4378 fbi: 0
CHANGE #4 CON_ID:3 TYP:0 CLS:30 AFN:11 DBA:0x02408512 OBJ:4294967295 SCN:0x00000000002586ff SEQ:1 OP:5.1 ENC:0 RBL:0 FLG:0x0c08
ktudb redo: siz: 140 spc: 4520 flg: 0x0012 seq: 0x0114 rec: 0x1c
            xid:  0x0007.005.00000327
ktubl redo: slt: 5 wrp: 1 flg: 0x0c08 prev dba: 0x00000000 rci: 0 opc: 11.1 [objn: 74451 objd: 74451 tsn: 5]
[Undo type  ] Regular undo  [User undo done   ]  No [Last buffer split]  No
[Temp object]           No  [Tablespace Undo  ]  No [User only        ]  No
Begin trans
 prev ctl uba: 0x02408512.0114.1b prev ctl max cmt scn:  0x0000000000256b31
 prev tx cmt scn:  0x0000000000256b42
 txn start scn:  0x00000000002587ab  logon user: 0
 prev brb:  0x02408511  prev bcl:  0x00000000
BuExt idx: 0 flg2: 0
KDO undo record:
KTB Redo
op: 0x03  ver: 0x01
compat bit: 4 (post-11) padding: 1
op: Z
KDO Op code: URP row dependencies Disabled
  xtype: XA flags: 0x00000000  bdba: 0x03000094  hdba: 0x03000092
itli: 2  ispac: 0  maxfr: 4858
tabn: 0 slot: 0(0x0) flag: 0x2c lock: 0 ckix: 0
ncol: 8 nnew: 2 size: -2
col  5: [ 2]  c2 33
col  6: *NULL*

Change # 1
PART   0[   70]:  11 0d 00 00 00 00 00 00 07 00 05 00 27 03 00 00 12 85 40 02 14 01 1c 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 01 0d 00 ac 87 25 00 00 80 00 00 01 06 00 80 9a 87 25 00 00 00 00 00 00 00 00
PART   1[   29]:  94 00 00 03 92 00 00 03 fa 12 05 01 02 00 00 00 2c 02 00 00 00 00 08 02 02 00 00 00 00
PART   2[    4]:  05 00 06 00
PART   3[    2]:  c2 3d
PART   4[    2]:  c2 33

Change # 2
PART   0[   32]:  05 00 00 00 27 03 00 00 12 85 40 02 14 01 1c 00 52 00 8c 00 00 00 01 00 00 00 00 00 00 00 00 00
PART   1[    4]:  47 92 da 2e

Change # 3
PART   0[   20]:  05 00 00 00 27 03 00 00 00 00 00 00 09 00 00 00 02 00 00 00
PART   1[   16]:  12 85 40 02 14 01 1c 00 2b 00 1a 11 00 00 38 00
PART   2[    4]:  4b b7 89 69

Change # 4
PART   0[   20]:  8c 00 a8 11 12 00 40 02 07 00 05 00 27 03 00 00 14 01 1c 00
PART   1[   76]:  d3 22 01 00 d3 22 01 00 05 00 00 00 00 00 00 00 0b 01 05 00 08 0c 01 00 00 00 00 00 12 85 40 02 14 01 1b 00 31 6b 25 00 00 00 00 00 42 6b 25 00 00 00 00 00 00 00 00 00 ab 87 25 00 00 00 00 00 11 85 40 02 00 00 00 00 00 00 00 00
PART   2[    8]:  03 0d 9b 70 00 00 00 00
PART   3[   29]:  94 00 00 03 92 00 00 03 fa 12 05 01 02 00 00 00 2c 00 00 00 00 00 08 02 fe ff 02 00 00
PART   4[    4]:  05 00 06 00
PART   5[    2]:  c2 33
PART   6[    0]:
```

Briefly about investigation method

- SCOTT.EMP table

```
CREATE TABLE EMP
       (EMPNO NUMBER(4) CONSTRAINT PK_EMP PRIMARY KEY,
          ENAME VARCHAR2(10),
          JOB VARCHAR2(9),
          MGR NUMBER(4),
          HIREDATE DATE,
          SAL NUMBER(7,2),
          COMM NUMBER(7,2),
          DEPTNO NUMBER(2) CONSTRAINT FK_DEPTNO REFERENCES DEPT);
```

- To understand the structure of operations with large objects
  - LOB = BLOB/CLOB/NCLOB/JSON/VECTOR/Extended size VARCHAR2/NVARCHAR2/RAW/Text XML

```
CREATE TABLE EMP
       (EMPNO NUMBER(4) CONSTRAINT PK_EMP PRIMARY KEY,
           ENAME VARCHAR2(10),
           JOB VARCHAR2(9),
           MGR NUMBER(4),
           HIREDATE DATE,
           SAL NUMBER(7,2),
           COMM NUMBER(7,2),
           AGREEMENT BLOB,
           DEPTNO NUMBER(2) CONSTRAINT FK_DEPTNO REFERENCES DEPT)
LOB(AGREEMENT) STORE AS
    SECUREFILE AGREEMENT_SF;
```

  - Binary XML

```
CREATE TABLE EMP
       (EMPNO NUMBER(4) CONSTRAINT PK_EMP PRIMARY KEY,
           ENAME VARCHAR2(10),
           JOB VARCHAR2(9),
           MGR NUMBER(4),
           HIREDATE DATE,
           SAL NUMBER(7,2),
           COMM NUMBER(7,2),
           AGREEMENT XMLTYPE,
           DEPTNO NUMBER(2) CONSTRAINT FK_DEPTNO REFERENCES DEPT)
XMLTYPE AGREEMENT  STORE AS BINARY XML;
```

Briefly about investigation method …contd…

- We will execute elementar SQL statements against database with V$DATABASE.SUPPLEMENTAL_LOG_DATA_MIN=NO and V$DATABASE.SUPPLEMENTAL_LOG_DATA_MIN=YES
  - “Plain vanilla”

```
select current_scn from v$database;
INSERT INTO EMP VALUES
(7839,'KING','PRESIDENT',NULL,to_date('17-11-1981','dd-mm-yyyy'),5000,NULL,10);
commit;
select current_scn from v$database;
UPDATE EMP SET COMM=5000,SAL=6000 WHERE EMPNO=7839;
commit;
select current_scn from v$database;
DELETE FROM EMP WHERE EMPNO=7839;
commit;
select current_scn from v$database;
```

  - “Plain vanilla” LOB

```
select current_scn from v$database;
INSERT INTO EMP VALUES
(7839,'KING','PRESIDENT',NULL,to_date('17-11-1981','dd-mm-yyyy'),5000,NULL, UTL_RAW.CAST_TO_RAW(RPAD('G',1000,'A')),10);
commit;
select current_scn from v$database;
UPDATE EMP SET COMM=5000,SAL=6000,AGREEMENT=UTL_RAW.CAST_TO_RAW(RPAD('G',1000,'B')) WHERE EMPNO=7839;
commit;
select current_scn from v$database;
DELETE FROM EMP WHERE EMPNO=7839;
commit;
select current_scn from v$database;
```

  - Binary XML

```
select current_scn from v$database;
INSERT INTO EMP VALUES
(7839,'KING','PRESIDENT',NULL,to_date('17-11-1981','dd-mm-yyyy'),5000,NULL, XMLType('<?xml version="1.0"?>
                    <PO pono="1">
                       <PNAME>Po_1</PNAME>
                       <CUSTNAME>SUN</CUSTNAME>
                       <SHIPADDR>
                          <STREET>1033, Main Street</STREET>
                          <CITY>Sunnyvalue</CITY>
                          <STATE>CA</STATE>
                       </SHIPADDR>
                    </PO>'),10);
commit;
select current_scn from v$database;
UPDATE EMP SET COMM=5000,SAL=6000,AGREEMENT=XMLType('<?xml version="1.0"?>
                    <PO pono="1">
                       <PNAME>Po_2</PNAME>
                       <CUSTNAME>Oracle</CUSTNAME>
                       <SHIPADDR>
                          <STREET>500, Twin Dolphin Drive</STREET>
                          <CITY>Belmont</CITY>
                          <STATE>CA</STATE>
                       </SHIPADDR>
                    </PO>') WHERE EMPNO=7839;
commit;
select current_scn from v$database;
DELETE FROM EMP WHERE EMPNO=7839;
commit;
select current_scn from v$database;
```

Briefly about investigation method …contd…

- For the approximate SCNs of the start and end of the transaction we have obtained, we will determine the file by querying V$LOG & V$LOGFILE or V$ARCHIVED_LOG
- Finally, we will use my tool to analyze internal structures

```
java -jar ~/oracdc-kafka-2.14.5-standalone.jar -f <REDO-LOG-FILE> -o <OUTPUT-FILE-NAME> -r -b --start-scn <START_SCN>
--end-scn <END_SCN>
```

  - Unlike the 'ALTER SYSTEM DUMP LOGFILE' command, it adds complete information about the redo record elements. For example

```
Change # 1
PART   0[   32]:  1a 00 00 00 09 03 00 00 1c 0c 40 02 29 01 12 00 52 00 70 00 00 00 00 00 00 00 00 00 00 00 00 00
PART   1[    4]:  47 92 da 2e

Change # 2
PART   0[   20]:  70 00 a8 17 12 00 00 00 05 00 1a 00 09 03 00 00 29 01 12 00
PART   1[   76]:  d3 22 01 00 d3 22 01 00 05 00 00 00 00 00 00 00 0b 01 1a 00 08 0c 01 00 00 00 00 00 1c 0c 40 02 29 01 0b 00 dc 65 25 00 00 00 00 00 22 6b 25 00 00 00 00 00 00 00 00 00 ff ff ff ff
ff ff ff ff 1b 0c 40 02 00 00 00 00 00 00 00 00
PART   2[    8]:  03 0d 00 00 00 00 00 00
PART   3[   20]:  94 00 00 03 92 00 00 03 fa 12 03 01 01 00 00 00 00 00 00 8e

Change # 3
PART   0[   24]:  01 0d 00 00 00 00 00 00 05 00 1a 00 09 03 00 00 1c 0c 40 02 29 01 12 00
PART   1[   49]:  94 00 00 03 92 00 00 03 fa 12 02 01 01 00 00 00 2c 01 08 00 00 00 00 00 60 00 00 00 00 00 00 00 00 00 00 00 00 00 02 00 00 00 26 00 00 00 00 48 00 00 f0
PART   2[    3]:  c2 4f 28
PART   3[    4]:  4b 49 4e 47
PART   4[    9]:  50 52 45 53 49 44 45 4e 54
PART   5[    0]:
PART   6[    7]:  77 b5 0b 11 01 01 01
PART   7[    2]:  c2 33
PART   8[    0]:
PART   9[    2]:  c1 0b
```

  - For more information - https://github.com/averemee-si/oracdc

Row and index (for IOT) operations - INSERT

```
select SUPPLEMENTAL_LOG_DATA_MIN from V$DATABASE;

SUPPLEMENTAL_LOG_DATA_MI
------------------------
NO
INSERT INTO EMP VALUES
(7839,'KING','PRESIDENT',NULL,to_date('17-11-1981','dd-mm-yyyy'),5000,NULL,10);
commit;



Change # 1
PART   0[   32]:  1a 00 00 00 09 03 00 00 1c 0c 40 02 29 01 12 00 52 00 70 00 00 00 00 00 00 00 00 00 00 00 00 00
PART   1[    4]:  47 92 da 2e

Change # 2
PART   0[   20]:  70 00 a8 17 12 00 00 00 05 00 1a 00 09 03 00 00 29 01 12 00
PART   1[   76]:  d3 22 01 00 d3 22 01 00 05 00 00 00 00 00 00 00 0b 01 1a 00 08 0c 01 00 00 00 00 00 1c 0c 40 02 29 01 0b 00 dc 65 25 00 00 00 00 00 22 6b 25 00 00 00 00 00 00 00 00
00 ff ff ff ff ff ff ff ff 1b 0c 40 02 00 00 00 00 00 00 00 00
PART   2[    8]:  03 0d 00 00 00 00 00 00
PART   3[   20]:  94 00 00 03 92 00 00 03 fa 12 03 01 01 00 00 00 00 00 00 8e

Change # 3
PART   0[   24]:  01 0d 00 00 00 00 00 00 05 00 1a 00 09 03 00 00 1c 0c 40 02 29 01 12 00
PART   1[   49]:  94 00 00 03 92 00 00 03 fa 12 02 01 01 00 00 00 2c 01 08 00 00 00 00 00 60 00 00 00 00 00 00 00 00 00 00 00 00 02 00 00 00 26 00 00 00 00 48 00 00 f0
PART   2[    3]:  c2 4f 28
PART   3[    4]:  4b 49 4e 47
PART   4[    9]:  50 52 45 53 49 44 45 4e 54
PART   5[    0]:
PART   6[    7]:  77 b5 0b 11 01 01 01
PART   7[    2]:  c2 33
PART   8[    0]:
PART   9[    2]:  c1 0b


CHANGE #1 CON_ID:3 TYP:0 CLS:25 AFN:11 DBA:0x024000c0 OBJ:4294967295 SCN:0x00000000002586fd SEQ:1 OP:5.2 ENC:0 RBL:0 FLG:0x0052

CHANGE #2 CON_ID:3 TYP:0 CLS:26 AFN:11 DBA:0x02400c1c OBJ:4294967295 SCN:0x00000000002586fc SEQ:7 OP:5.1 ENC:0 RBL:0 FLG:0x0c08

CHANGE #3 CON_ID:3 TYP:0 CLS:1 AFN:12 DBA:0x03000094 OBJ:74451 SCN:0x0000000000258799 SEQ:2 OP:11.2 ENC:0 RBL:0 FLG:0x0000
```

Row and index (for IOT) operations - INSERT

```
select SUPPLEMENTAL_LOG_DATA_MIN from V$DATABASE;

SUPPLEMENTAL_LOG_DATA_MI
------------------------
YES
INSERT INTO EMP VALUES
(7839,'KING','PRESIDENT',NULL,to_date('17-11-1981','dd-mm-yyyy'),5000,NULL,10);
commit;



PART   0[   32]:  13 00 00 00 60 03 00 00 17 16 40 02 27 01 0f 00 52 00 88 00 00 00 00 00 00 00 00 00 00 00 00 00
PART   1[    4]:  47 92 da 2e

Change # 2
PART   0[   20]:  88 00 f2 15 12 00 00 00 07 00 13 00 60 03 00 00 27 01 0f 00
PART   1[   76]:  f8 22 01 00 f8 22 01 00 05 00 00 00 00 00 00 00 0b 01 13 00 08 0c 01 00 00 00 00 00 17 16 40 02 27 01 0e 00 fe 59 27 00 00 00 00 00 fa 5b 27 00 00 00 00 00 00 00 00 ff ff ff ff ff
ff ff ff 11 16 40 02 00 00 00 00 00 00 00 00
PART   2[    8]:  03 0d 00 00 00 00 00 00
PART   3[   20]:  c4 01 00 03 c2 01 00 03 fa 12 23 01 01 00 00 00 00 00 00 00
PART   4[   20]:  02 1c 00 00 01 00 00 00 01 00 00 00 00 00 00 00 00 02 00 00

Change # 3
PART   0[   24]:  01 0d 00 00 00 00 00 00 07 00 13 00 60 03 00 00 17 16 40 02 27 01 0f 00
PART   1[   49]:  c4 01 00 03 c2 01 00 03 fa 12 02 01 01 00 00 00 2c 01 08 00 00 00 00 00 60 00 00 00 00 00 00 00 00 00 00 00 00 00 02 00 00 00 26 00 00 00 00 48 00 00 f0
PART   2[    3]:  c2 4f 28
PART   3[    4]:  4b 49 4e 47
PART   4[    9]:  50 52 45 53 49 44 45 4e 54
PART   5[    0]:
PART   6[    7]:  77 b5 0b 11 01 01 01
PART   7[    2]:  c2 33
PART   8[    0]:
PART   9[    2]:  c1 0b



CHANGE #1 CON_ID:3 TYP:0 CLS:29 AFN:11 DBA:0x024000e0 OBJ:4294967295 SCN:0x00000000002784c2 SEQ:1 OP:5.2 ENC:0 RBL:0 FLG:0x0052

CHANGE #2 CON_ID:3 TYP:0 CLS:30 AFN:11 DBA:0x02401617 OBJ:4294967295 SCN:0x00000000002784c1 SEQ:1 OP:5.1 ENC:0 RBL:0 FLG:0x0c08

CHANGE #3 CON_ID:3 TYP:0 CLS:1 AFN:12 DBA:0x030001c4 OBJ:74488 SCN:0x000000000027871e SEQ:2 OP:11.2 ENC:0 RBL:0 FLG:0x0000
```

Row and index (for IOT) operations - UPDATE

```
select SUPPLEMENTAL_LOG_DATA_MIN from V$DATABASE;

SUPPLEMENTAL_LOG_DATA_MI
------------------------
NO
UPDATE EMP SET COMM=5000,SAL=6000 WHERE EMPNO=7839;
commit;



Change # 1
PART   0[   70]:  11 0d 00 00 00 00 00 00 07 00 05 00 27 03 00 00 12 85 40 02 14 01 1c 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 01 0d 00 ac 87 25 00 00 80 00 00 01 06 00 80 9a 87 25 00 00 00 00 00
00 00
PART   1[   29]:  94 00 00 03 92 00 00 03 fa 12 05 01 02 00 00 00 2c 02 00 00 00 00 08 02 02 00 00 00 00
PART   2[    4]:  05 00 06 00
PART   3[    2]:  c2 3d
PART   4[    2]:  c2 33

Change # 2
PART   0[   32]:  05 00 00 00 27 03 00 00 12 85 40 02 14 01 1c 00 52 00 8c 00 00 00 01 00 00 00 00 00 00 00 00 00
PART   1[    4]:  47 92 da 2e

Change # 3
PART   0[   20]:  05 00 00 00 27 03 00 00 00 00 00 00 09 00 00 00 02 00 00 00
PART   1[   16]:  12 85 40 02 14 01 1c 00 2b 00 1a 11 00 00 38 00
PART   2[    4]:  4b b7 89 69

Change # 4
PART   0[   20]:  8c 00 a8 11 12 00 40 02 07 00 05 00 27 03 00 00 14 01 1c 00
PART   1[   76]:  d3 22 01 00 d3 22 01 00 05 00 00 00 00 00 00 00 00 0b 01 05 00 08 0c 01 00 00 00 00 00 12 85 40 02 14 01 1b 00 31 6b 25 00 00 00 00 00 42 6b 25 00 00 00 00 00 00 00 00 00 ab 87 25 00 00 00 00 00 11 85 40 02
00 00 00 00 00 00 00 00
PART   2[    8]:  03 0d 9b 70 00 00 00 00
PART   3[   29]:  94 00 00 03 92 00 00 03 fa 12 05 01 02 00 00 00 2c 00 00 00 00 00 08 02 fe ff 02 00 00
PART   4[    4]:  05 00 06 00
PART   5[    2]:  c2 33
PART   6[    0]:



CHANGE #1 CON_ID:3 TYP:2 CLS:1 AFN:12 DBA:0x03000094 OBJ:74451 SCN:0x000000000025879a SEQ:1 OP:11.5 ENC:0 RBL:0 FLG:0x0000

CHANGE #2 CON_ID:3 TYP:0 CLS:29 AFN:11 DBA:0x024000e0 OBJ:4294967295 SCN:0x0000000000258700 SEQ:1 OP:5.2 ENC:0 RBL:0 FLG:0x0052

CHANGE #3 CON_ID:3 TYP:0 CLS:29 AFN:11 DBA:0x024000e0 OBJ:4294967295 SCN:0x00000000002587ae SEQ:1 OP:5.4 ENC:0 RBL:0 FLG:0x0002

CHANGE #4 CON_ID:3 TYP:0 CLS:30 AFN:11 DBA:0x02408512 OBJ:4294967295 SCN:0x00000000002586ff SEQ:1 OP:5.1 ENC:0 RBL:0 FLG:0x0c08
```

Row and index (for IOT) operations - UPDATE

```
select SUPPLEMENTAL_LOG_DATA_MIN from V$DATABASE;

SUPPLEMENTAL_LOG_DATA_MI
------------------------
YES
UPDATE EMP SET COMM=5000,SAL=6000 WHERE EMPNO=7839;
commit;



Change # 1
PART   0[   32]:  16 00 14 8f a2 03 00 00 cf 1a 40 02 bc 01 02 00 52 00 a0 00 00 00 00 00 00 00 00 00 00 00 00 00
PART   1[    4]:  47 92 da 2e

Change # 2
PART   0[   20]:  a0 00 a0 1e 12 00 00 00 03 00 16 00 a2 03 00 00 bc 01 02 8e
PART   1[   76]:  f8 22 01 00 f8 22 01 00 05 00 00 00 00 00 00 00 0b 01 16 00 08 0c 01 00 00 00 00 00 cf 1a 40 02 bc 01 01 00 af 77 27 00 00 00 00 00 25 78 27 00 00 00 00 00 fd 7f 00
00 ff ff ff ff ff ff ff cc 1a 40 02 00 00 00 00 00 00 00 00
PART   2[    8]:  03 0d 40 02 ec 86 27 00
PART   3[   29]:  c4 01 00 03 c2 01 00 03 fa 12 25 01 02 00 00 00 2c 00 00 00 00 00 08 02 fe ff 02 00 00
PART   4[    4]:  05 00 06 00
PART   5[    2]:  c2 33
PART   6[    0]:
PART   7[   20]:  01 1c 00 00 01 00 06 00 06 00 00 00 00 10 00 00 00 02 00 00

Change # 3
PART   0[   70]:  11 0d 00 00 08 00 3f 00 03 00 16 00 a2 03 00 00 cf 1a 40 02 bc 01 02 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 01 0d 8e 2b 87 27 00 00 80 00
00 01 06 00 80 1f 87 27 00 00 00 00 00 00 00 00
PART   1[   29]:  c4 01 00 03 c2 01 00 03 fa 12 05 01 02 00 00 00 2c 02 00 00 00 00 08 02 02 00 00 00 00
PART   2[    4]:  05 00 06 00
PART   3[    2]:  c2 3d
PART   4[    2]:  c2 33



CHANGE #1 CON_ID:3 TYP:0 CLS:21 AFN:11 DBA:0x024000a0 OBJ:4294967295 SCN:0x000000000027867a SEQ:1 OP:5.2 ENC:0 RBL:0 FLG:0x0052

CHANGE #2 CON_ID:3 TYP:0 CLS:22 AFN:11 DBA:0x02401acf OBJ:4294967295 SCN:0x0000000000278678 SEQ:2 OP:5.1 ENC:0 RBL:0 FLG:0x0c08

CHANGE #3 CON_ID:3 TYP:2 CLS:1 AFN:12 DBA:0x030001c4 OBJ:74488 SCN:0x000000000027871f SEQ:1 OP:11.5 ENC:0 RBL:0 FLG:0x0000
```

Row and index (for IOT) operations - DELETE

```
select SUPPLEMENTAL_LOG_DATA_MIN from V$DATABASE;

SUPPLEMENTAL_LOG_DATA_MI
SUPPLEMENTAL_LOG_DATA_MI
------------------------
NO
DELETE FROM EMP WHERE EMPNO=7839;
commit;



Change # 1
PART   0[   70]:  11 0d 00 00 00 00 00 00 04 00 0f 00 1a 03 00 00 b5 00 40 02 e3 00 06 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 01 0d 00 b5 87 25 00 00 80 00 00 02 06 00 80 ae
87 25 00 00 00 00 00 00
PART   1[   20]:  94 00 00 03 92 00 00 03 fa 12 03 01 01 00 00 00 00 00 00 00

Change # 2
PART   0[   32]:  0f 00 00 00 1a 03 00 00 b5 00 40 02 e3 00 06 00 52 00 e0 00 00 00 00 00 00 00 00 00 00 00 00 00
PART   1[    4]:  47 92 da 2e

Change # 3
PART   0[   20]:  e0 00 d4 1d 12 00 00 00 04 00 0f 00 1a 03 00 00 e3 00 06 00
PART   1[   76]:  d3 22 01 00 d3 22 01 00 05 00 00 00 00 00 00 00 0b 01 0f 00 08 0c 01 00 00 00 00 00 b5 00 40 02 e3 00 05 00 0a 84 25 00 00 00 00 00 21 84 25 00 00 00 00 00 00 00 00 00 b3 87 25 00 00
00 00 00 b4 00 40 02 00 00 00 00 00 00 00 00
PART   2[   32]:  04 0d 00 00 00 00 00 00 05 00 1a 00 09 03 00 00 1c 0c 40 02 29 01 12 00 00 80 00 80 9a 87 25 00
PART   3[   49]:  94 00 00 03 92 00 00 03 fa 12 02 01 01 00 00 00 2c 00 08 76 00 00 00 00 00 55 08 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 28 00 00 00 00 08 00 00 00
PART   4[    3]:  c2 4f 28
PART   5[    4]:  4b 49 4e 47
PART   6[    9]:  50 52 45 53 49 44 45 4e 54
PART   7[    0]:
PART   8[    7]:  77 b5 0b 11 01 01 01
PART   9[    2]:  c2 3d
PART  10[    2]:  c2 33
PART  11[    2]:  c1 0b



CHANGE #1 CON_ID:3 TYP:2 CLS:1 AFN:12 DBA:0x03000094 OBJ:74451 SCN:0x00000000002587ae SEQ:2 OP:11.3 ENC:0 RBL:0 FLG:0x0000

CHANGE #2 CON_ID:3 TYP:0 CLS:23 AFN:11 DBA:0x024000b0 OBJ:4294967295 SCN:0x0000000000258793 SEQ:1 OP:5.2 ENC:0 RBL:0 FLG:0x0052

CHANGE #3 CON_ID:3 TYP:0 CLS:24 AFN:11 DBA:0x024000b5 OBJ:4294967295 SCN:0x0000000000258790 SEQ:1 OP:5.1 ENC:0 RBL:0 FLG:0x0c08
```

Row and index (for IOT) operations - DELETE

```
select SUPPLEMENTAL_LOG_DATA_MIN from V$DATABASE;

SUPPLEMENTAL_LOG_DATA_MI
SUPPLEMENTAL_LOG_DATA_MI
------------------------
YES
DELETE FROM EMP WHERE EMPNO=7839;
commit;



Change # 1
PART   0[   32]:  19 00 d6 6c 48 03 00 00 9e 12 40 02 01 01 20 00 52 00 f8 00 00 00 00 00 00 00 00 00 00 00 00
PART   1[    4]:  47 92 da 2e

Change # 2
PART   0[   20]:  f8 00 24 09 12 00 00 00 09 00 19 00 48 03 00 00 01 01 20 00
PART   1[   76]:  f8 22 01 00 f8 22 01 00 05 00 00 00 00 00 00 00 0b 01 19 00 08 0c 01 00 00 00 00 00 9e 12 40 02 01 01 1f 00 c4 77 27 00 00 00 00 00 22 82 27 00 00 00 00 00 32 5d c6 19 ff ff ff ff ff
ff ff ff 9a 12 40 02 00 00 00 00 00 00 00 00
PART   2[   32]:  04 0d 00 00 00 00 00 00 07 00 13 00 60 03 00 00 17 16 40 02 27 01 0f 00 00 80 00 80 1f 87 27 00
PART   3[   49]:  c4 01 00 03 c2 01 00 03 fa 12 22 01 01 00 00 00 2c 00 08 78 00 00 00 00 55 08 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 28 00 00 00 00 08 00 00 00
PART   4[    3]:  c2 4f 28
PART   5[    4]:  4b 49 4e 47
PART   6[    9]:  50 52 45 53 49 44 45 4e 54
PART   7[    0]:
PART   8[    7]:  77 b5 0b 11 01 01 01
PART   9[    2]:  c2 3d
PART  10[    2]:  c2 33
PART  11[    2]:  c1 0b
PART  12[   20]:  04 1c 00 00 01 00 01 00 00 00 00 00 00 00 00 00 00 02 00 00

Change # 3
PART   0[   70]:  11 0d 00 00 00 00 00 00 09 00 19 00 48 03 00 00 9e 12 40 02 01 01 20 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 01 0d 00 32 87 27 00 00 80 00 00 02 06 00 80 2c
87 27 00 00 00 00 00 00 00
PART   1[   20]:  c4 01 00 03 c2 01 00 03 fa 12 03 01 01 00 00 00 00 00 00 00


CHANGE #1 CON_ID:3 TYP:0 CLS:33 AFN:11 DBA:0x02400100 OBJ:4294967295 SCN:0x00000000002784c6 SEQ:1 OP:5.2 ENC:0 RBL:0 FLG:0x0052

CHANGE #2 CON_ID:3 TYP:0 CLS:34 AFN:11 DBA:0x0240129e OBJ:4294967295 SCN:0x00000000002784c5 SEQ:1 OP:5.1 ENC:0 RBL:0 FLG:0x0c08

CHANGE #3 CON_ID:3 TYP:2 CLS:1 AFN:12 DBA:0x030001c4 OBJ:74488 SCN:0x000000000027872c SEQ:1 OP:11.3 ENC:0 RBL:0 FLG:0x0000
```

Row and index (for IOT) operations

What is the effect of executing the command '**`alter system add supplemental log data`**'?

- All data modification operations were supplemented with a new structure of 20 or 28 bytes (if **`DBA`** and **`slot`** are present) in length

pos	type	meaning
0	uint8	Operation • 0x1 UPDATE • 0x2 INSERT • 0x4 DELETE • 0x10 LOCK
1	uint8	fb (row flag)
2	uint8	Number of columns supplementally logged
6-7	uint16	segcol# in undo start
8-9	uint16	segcol# in undo start
20-23	uint32	DBA
24-25	uint16	slot

Row and index (for IOT) operations …contd…

What is the effect of executing the command '`alter database add supplemental log data`'? Help in solving Oracle Database phenomenons

- Operation indicator
  - Yes, just like in PostgreSQL an UPDATE operation can be combination of a DELETE and INSERT (more precisely OP:11.3 DRP + OP:11.2 IRP/OP 11.6 ORP)
- **fb** (row flag) along with starting segcol# number for undo and redo provide hints for combining multiply redo records into a single INSERT/UPDATE/DELETE operation
- DBA and slot help in generating the correct ROWID
- We do not consider adding supplemental log data about table columns without which it is impossible to restore UPDATE
  - alter table <TABLE_NAME> add supplemental log data (primary key|unique|foreign key) columns
  - alter table <TABLE_NAME> add supplemental log group <GROUP_NAME> (<COLUMN_LIST>) ALWAYS;
  - alter table <TABLE_NAME> add supplemental log data (ALL) columns
- Last but not the least - the same results on RDBMS 19.30 with

```
alter system set enable_goldengate_replication=true;

alter database add supplemental log data subset database replication;
```

Row and index (for IOT) operations …contd…

OP:5.4 RCM (**R**ollback **C**ommit **M**anagement)

- When supplemental log data was not set OP:5.4 was often combined with other change vectors

```
CHANGE #1 CON_ID:3 TYP:2 CLS:1 AFN:12 DBA:0x03000094 OBJ:74451 SCN:0x000000000025879a SEQ:1 OP:11.5 ENC:0 RBL:0 FLG:0x0000

CHANGE #2 CON_ID:3 TYP:0 CLS:29 AFN:11 DBA:0x024000e0 OBJ:4294967295 SCN:0x0000000000258700 SEQ:1 OP:5.2 ENC:0 RBL:0 FLG:0x0052

CHANGE #3 CON_ID:3 TYP:0 CLS:29 AFN:11 DBA:0x024000e0 OBJ:4294967295 SCN:0x00000000002587ae SEQ:1 OP:5.4 ENC:0 RBL:0 FLG:0x0002

CHANGE #4 CON_ID:3 TYP:0 CLS:30 AFN:11 DBA:0x02408512 OBJ:4294967295 SCN:0x00000000002586ff SEQ:1 OP:5.1 ENC:0 RBL:0 FLG:0x0c08
```

- After setting supplemental log data OP:5.4 is separate redo record accompanied with OP:24.4 (LMNR xact finalize marker)

```
REDO RECORD - Thread:1 RBA: 0x00000d.0004357d.012c LEN: 0x00b8 VLD: 0x01 CON_UID: 786076231
SCN: 0x000000000027c6c3 SUBSCN: 1
CHANGE #1 CON_ID:3 TYP:0 CLS:31 AFN:11 DBA:0x024000f0 OBJ:4294967295 SCN:0x000000000027c6c2 SEQ:2 OP:5.4 ENC:0 RBL:0 FLG:0x0002
ktucm redo: slt: 0x001b sqn: 0x0000037d srt: 0 sta: 9 flg: 0x2 ktucf redo: uba: 0x02402126.0136.1b ext: 16 spc: 2800 fbi: 0
CHANGE #2 MEDIA RECOVERY MARKER CON_ID:3 SCN:0x0000000000000000 SEQ:0 OP:24.4 ENC:0 FLG:0x0000
LMNR xact finalize marker:  xid: 0x0008.01b.0000037d outcome: 1 - COMMIT  start scn: 0x000000000027c6c2
Change # 1
PART   0[   20]:  1b 00 00 00 7d 03 00 00 00 00 00 00 09 00 00 00 02 00 00 00
PART   1[   16]:  26 21 40 02 36 01 1b 00 10 00 f0 0a 00 00 00 00
PART   2[    4]:  dc 1e 91 69

Change # 2
PART   0[   16]:  28 23 00 00 08 00 1b 00 7d 03 00 00 ff 00 0e 00
PART   1[    4]:  01 0a 09 00
PART   2[    6]:  00 00 01 00 00 00
PART   3[    8]:  c2 c6 27 00 00 00 00 00
```

- After setting supplemental log data OP:24.4 is used as the start-of-transaction marker for many transactions.

LOBs

When supplemental log data was not set, it works the same as for tables without LOB columns, except that OP:26.2/OP:26.6 change events are added for LOBs stored out-of-row.

If we set supplemental log data (V$DATABASE.SUPPLEMENTAL_LOG_DATA_MIN) the situation is getting worse in terms of IO load for INSERT and UPDATE (new LID!)

```
REDO RECORD - Thread:1 RBA: 0x00000d.00035eca.0178 LEN: 0x00e8 VLD: 0x01 CON_UID: 786076231
SCN: 0x0000000000279741 SUBSCN: 2
CHANGE #1 MEDIA RECOVERY MARKER CON_ID:3 SCN:0x0000000000000000 SEQ:0 OP:11.17 ENC:0 FLG:0x0000
  typ:4 xid:0x0006.014.00000351 obj:74490 LOB_cc:1 LOB_col ids: [8]
REDO RECORD - Thread:1 RBA: 0x00000d.00035ecb.0070 LEN: 0x00b0 VLD: 0x01 CON_UID: 786076231
SCN: 0x0000000000279741 SUBSCN: 3
CHANGE #1 MEDIA RECOVERY MARKER CON_ID:3 SCN:0x0000000000000000 SEQ:0 OP:11.17 ENC:0 FLG:0x0000
  typ:1 xid:0x0006.014.00000351 obj:74490 prepare write to lid:00000001000000102e33 fsiz:1000
  column_id: 8
REDO RECORD - Thread:1 RBA: 0x00000d.00035ecb.0120 LEN: 0x0078 VLD: 0x01 CON_UID: 786076231
SCN: 0x0000000000279741 SUBSCN: 4
CHANGE #1 MEDIA RECOVERY MARKER CON_ID:3 SCN:0x0000000000000000 SEQ:0 OP:11.17 ENC:0 FLG:0x0000
  typ:3 xid:0x0006.014.00000351 obj:74490 fsiz:1000
  column_id: 8
REDO RECORD - Thread:1 RBA: 0x00000d.00035ecf.003c LEN: 0x0594 VLD: 0x01 CON_UID: 786076231
...
CHANGE #3 CON_ID:3 TYP:0 CLS:1 AFN:12 DBA:0x030001d4 OBJ:74490 SCN:0x0000000000279743 SEQ:2 OP:11.2 ENC:0 RBL:0 FLG:0x0000
```

Nothing special for DELETE

LOBs - OP:11.17 typ:4

This redo record is generated once per operation and contains all changed column values before and after the operation, excluding LOB column values. It describes the state of the row before selecting the LID from the SYS.IDGEN1$ sequence. The actual redo record (OP:5.1+OP:11.[2|5|6]) of the operation will include the same values and the LID obtained from SYS.IDGEN1$.

INSERT

```
REDO RECORD - Thread:1 RBA: 0x00000d.00035eca.0178 LEN: 0x00e8 VLD: 0x01 CON_UID: 786076231
SCN: 0x0000000000279741 SUBSCN: 2
CHANGE #1 MEDIA RECOVERY MARKER CON_ID:3 SCN:0x0000000000000000 SEQ:0 OP:11.17 ENC:0 FLG:0x0000
  typ:4 xid:0x0006.014.00000351 obj:74490 LOB_cc:1 LOB_col_ids: [8]
Change # 1
PART   0[   16]:  00 00 00 00 00 00 00 00 00 00 31 01 00 00 00 00
PART   1[    1]:  04
PART   2[   40]:  fa 22 01 00 01 00 00 00 06 00 14 00 51 03 00 00 02 00 01 00 00 00 08 00 00 00 00 00 0c 00 0c 11 00 00 00 00 00 00 00 00
PART   3[    2]:  08 00
PART   4[    0]:
PART   5[   16]:  01 00 02 00 03 00 04 00 05 00 06 00 07 00 09 00
PART   6[   16]:  03 00 04 00 09 00 ff ff 07 00 02 00 ff ff 02 00
PART   7[    2]:  00 00
PART   8[    0]:
PART   9[    0]:
PART  10[    0]:
PART  11[    3]:  c2 4f 28
PART  12[    4]:  4b 49 4e 47
PART  13[    9]:  50 52 45 53 49 44 45 4e 54
PART  14[    0]:
PART  15[    7]:  77 b5 0b 11 01 01 01
PART  16[    2]:  c2 33
PART  17[    0]:
PART  18[    2]:  c1 0b
```

LOBs - OP:11.17 typ:4

UPDATE

```
REDO RECORD - Thread:1 RBA: 0x00000d.00035ee0.00d8 LEN: 0x00b8 VLD: 0x01 CON_UID: 786076231
SCN: 0x0000000000279753 SUBSCN: 2
CHANGE #1 MEDIA RECOVERY MARKER CON_ID:3 SCN:0x0000000000000000 SEQ:0 OP:11.17 ENC:0 FLG:0x0000
  typ:4 xid:0x0003.00c.000003a3 obj:74490 LOB_cc:1 LOB_col_ids: [8]
Content:
B8000000010000005397270002000008479 2DA2E00001C450B1100000000000000000000000000000000000000000000000000600000300000000000000020001000010028000200000008000800020000000000000
0002000200020000000000000000000000000000031010000000004 00FFFFFA2201000100000003000C00A303000001000100000002000200000 0C0008110000000000000000800000006000700060007000200020002000200FFFF00008207C23D0000C2339169C2330000
Change # 1
PART   0[   16]:  00 00 00 00 00 00 00 00 00 00 31 01 00 00 00 00
PART   1[    1]:  04
PART   2[   40]:  fa 22 01 00 01 00 00 00 03 00 0c 00 a3 03 00 00 01 00 01 00 00 00 02 00 02 00 00 00 0c 00 08 11 00 00 00 00 00 00 00 00
PART   3[    2]:  08 00
PART   4[    0]:
PART   5[    8]:  06 00 07 00 06 00 07 00
PART   6[    8]:  02 00 02 00 02 00 ff ff
PART   7[    2]:  00 00
PART   8[    0]:
PART   9[    0]:
PART  10[    0]:
PART  11[    2]:  c2 3d
PART  12[    2]:  c2 33
PART  13[    2]:  c2 33
PART  14[    0]:
```

LOBs - OP:11.17 typ:1 and typ:3

OP:11.17 typ:1 - LOB data writing start marker

```
REDO RECORD - Thread:1 RBA: 0x00000d.00035ecb.0070 LEN: 0x00b0 VLD: 0x01 CON_UID: 786076231
SCN: 0x0000000000279741 SUBSCN: 3
CHANGE #1 MEDIA RECOVERY MARKER CON_ID:3 SCN:0x0000000000000000 SEQ:0 OP:11.17 ENC:0 FLG:0x0000
  typ:1 xid:0x0006.014.00000351 obj:74490 prepare write to lid:00000001000000102e33 fsiz:1000
  column_id: 8
Change # 1
PART   0[   16]:  00 00 00 00 00 00 00 00 00 00 31 01 00 00 00 00
PART   1[    1]:  01
PART   2[   80]:  02 00 00 00 06 00 14 00 51 03 00 00 00 00 00 01 00 00 00 10 2e 33 08 00 01 00 00 00 7c 1f 00 00 e8 03 00 00 fa 22 01 00 01 00 00 00 00 00 00
00 01 00 00 00 01 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 40 00 00 00 00 00 00 00 00 00 00 00 00
PART   3[    8]:  00 00 00 00 00 00 00 00
```

OP:11.17 typ:3 - LOB data writing end marker

```
REDO RECORD - Thread:1 RBA: 0x00000d.00035ecb.0120 LEN: 0x0078 VLD: 0x01 CON_UID: 786076231
SCN: 0x0000000000279741 SUBSCN: 4
CHANGE #1 MEDIA RECOVERY MARKER CON_ID:3 SCN:0x0000000000000000 SEQ:0 OP:11.17 ENC:0 FLG:0x0000
  typ:3 xid:0x0006.014.00000351 obj:74490 fsiz:1000
  column_id: 8
Change # 1
PART   0[   16]:  00 00 00 00 00 00 00 00 00 00 31 01 00 00 00 00
PART   1[    1]:  03
PART   2[   36]:  06 00 14 00 51 03 00 00 fa 22 01 00 e8 03 00 00 00 00 00 00 46 00 00 00 00 00 00 00 00 00 00 00 01 00 08 00
```

LOBs - last step with supplemental log data set

```
REDO RECORD - Thread:1 RBA: 0x00000d.00035ecf.003c LEN: 0x0594 VLD: 0x01 CON_UID: 786076231
SCN: 0x0000000000279743 SUBSCN: 8
CHANGE #1 CON_ID:3 TYP:0 CLS:27 AFN:11 DBA:0x024000d0 OBJ:4294967295 SCN:0x0000000000279742 SEQ:1 OP:5.2 ENC:0 RBL:0 FLG:0x0002
ktudh redo: slt: 0x0014 sqn: 0x00000000 flg: 0x0002 siz: 84 fbi: 0
            uba: 0x024020cf.00db.1e    pxid:  0x0000.000.00000000
CHANGE #2 CON_ID:3 TYP:0 CLS:28 AFN:11 DBA:0x024020cf OBJ:4294967295 SCN:0x0000000000279741 SEQ:1 OP:5.1 ENC:0 RBL:0 FLG:0x0000
ktudb redo: siz: 84 spc: 2288 flg: 0x0022 seq: 0x00db rec: 0x1e
            xid:  0x0006.014.00000351
ktubu redo: slt: 20 wrp: 849 flg: 0x0000 prev dba: 0x00000000 rci: 0 opc: 11.1 [objn: 74490 objd: 74490 tsn: 5]
[Undo type  ] Regular undo  [User undo done   ]  No [Last buffer split]  No
[Temp object]           No  [Tablespace Undo  ]  No [User only        ]  No
KDO undo record:
KTB Redo
op: 0x03  ver: 0x01
compat bit: 4 (post-11) padding: 1
op: Z
KDO Op code: DRP row dependencies Disabled
  xtype: XA flags: 0x00000000  bdba: 0x030001d4  hdba: 0x030001d2
itli: 1  ispac: 0  maxfr: 4858
tabn: 0 slot: 0(0x0)
LOGMINER DATA:
 Number of columns supplementally logged: 0
opcode: INSERT
 segcol# in Undo starting from 0
 segcol# in Redo starting from 1
 pos: 4 fb: ---DFL--
CHANGE #3 CON_ID:3 TYP:0 CLS:1 AFN:12 DBA:0x030001d4 OBJ:74490 SCN:0x0000000000279743 SEQ:2 OP:11.2 ENC:0 RBL:0 FLG:0x0000
KTB Redo
op: 0x01  ver: 0x01
compat bit: 4 (post-11) padding: 1
op: F  xid:  0x0006.014.00000351    uba: 0x024020cf.00db.1e
KDO Op code: IRP row dependencies Disabled
  xtype: XA flags: 0x00000000  bdba: 0x030001d4  hdba: 0x030001d2
itli: 1  ispac: 0  maxfr: 4858
tabn: 0 slot: 0(0x0) size/delt: 1072
fb: --H-FL-- lb: 0x1  cc: 9
null: ---N--N--
col  0: [ 3]  c2 4f 28
col  1: [ 4]  4b 49 4e 47
col  2: [ 9]  50 52 45 53 49 44 45 4e 54
col  3: *NULL*
col  4: [ 7]  77 b5 0b 11 01 01 01
col  5: [ 2]  c2 33
col  6: *NULL*
col  7: [1031]
 00 70 00 01 01 0c 00 80 00 01 00 00 00 01 00 00 00 10 2e 33 03 f3 48 90 03 ed 01 00 03 e8 01 47 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
 41 41 41 41 41 41
col  8: [ 2]  c1 0b
```

LOBs - last step with supplemental log data set

```
Change # 1
PART   0[   32]:  14 00 00 00 00 00 00 00 cf 20 40 02 db 00 1e 00 02 00 54 00 00 00 00 00 00 00 00 00 00 00 00 00

Change # 2
PART   0[   20]:  54 00 f0 08 22 00 00 00 06 00 14 00 51 03 00 00 db 00 1e 00
PART   1[   24]:  fa 22 01 00 fa 22 01 00 05 00 00 00 00 00 00 00 0b 01 14 00 00 00 51 03
PART   2[    8]:  03 0d 00 00 00 00 00 00
PART   3[   20]:  d4 01 00 03 d2 01 00 03 fa 12 23 01 01 00 00 00 00 00 00 00
PART   4[   20]:  02 1c 00 00 01 00 00 00 01 00 00 00 00 00 00 00 00 02 00 00

Change # 3
PART   0[   24]:  01 0d 00 00 00 00 00 00 06 00 14 00 51 03 00 00 cf 20 40 02 db 00 1e 00
PART   1[   50]:  d4 01 00 03 d2 01 00 03 fa 12 02 01 01 00 00 00 2c 01 09 00 00 00 00 00 60 00 00 00 00 00 00 00 00 00 00 00 02 00 00 00 30 04 00 00 00 48 00 00 f0
7b
PART   2[    3]:  c2 4f 28
PART   3[    4]:  4b 49 4e 47
PART   4[    9]:  50 52 45 53 49 44 45 4e 54
PART   5[    0]:
PART   6[    7]:  77 b5 0b 11 01 01 01
PART   7[    2]:  c2 33
PART   8[    0]:
PART   9[ 1031]:  00 70 00 01 01 0c 00 80 00 01 00 00 00 01 00 00 00 10 2e 33 03 f3 48 90 03 ed 01 00 03 e8 01 47 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
PART  10[    2]:  c1 0b

CHANGE #1 CON_ID:3 TYP:0 CLS:27 AFN:11 DBA:0x024000d0 OBJ:4294967295 SCN:0x0000000000279742 SEQ:1 OP:5.2 ENC:0 RBL:0 FLG:0x0002
CHANGE #2 CON_ID:3 TYP:0 CLS:28 AFN:11 DBA:0x024020cf OBJ:4294967295 SCN:0x0000000000279741 SEQ:1 OP:5.1 ENC:0 RBL:0 FLG:0x0000
CHANGE #3 CON_ID:3 TYP:0 CLS:1 AFN:12 DBA:0x030001d4 OBJ:74490 SCN:0x0000000000279743 SEQ:2 OP:11.2 ENC:0 RBL:0 FLG:0x0000
```

LOBs - without supplemental log data

Just one redo record

```
Change # 1
PART    0[   32]:  12 00 00 00 6e 03 00 00 d8 11 40 02 aa 01 01 00 4a 00 70 00 00 00 00 00 00 00 00 00 00 00 00 00
PART    1[   36]:  07 00 00 00 02 00 00 00 00 00 00 00 08 00 00 00 d8 11 40 02 00 00 00 00 02 00 00 00 00 00 00 00 00 00 00 00
PART    2[    4]:  47 92 da 2e

Change # 2
PART    0[   20]:  70 00 00 00 0a 00 00 00 03 00 12 00 6e 03 00 00 aa 01 01 00
PART    1[   76]:  de 22 01 00 de 22 01 00 05 00 00 00 00 00 00 00 0b 01 12 00 08 0c 01 00 00 00 00 00 ad 00 40 02 a9 01 59 00 35 97 25 00 00 00 00 00 4d 97 25 00 00 00 00 00 00 00 00 00 ff ff ff ff
ff ff ff ff ac 00 40 02 00 00 00 00 00 00 00 00
PART    2[    8]:  03 0d 40 02 14 01 51 00
PART    3[   20]:  f4 00 00 03 f2 00 00 03 fa 12 03 01 01 00 00 00 00 00 00 00

Change # 3
PART    0[   24]:  01 0d 00 00 00 00 00 00 03 00 12 00 6e 03 00 00 d8 11 40 02 aa 01 01 00
PART    1[   50]:  f4 00 00 03 f2 00 00 03 fa 12 02 01 01 00 00 00 2c 01 09 00 00 00 00 00 60 00 00 00 00 00 00 00 00 00 00 00 02 00 00 00 30 04 00 00 00 48 00 00 f0 3b
PART    2[    3]:  c2 4f 28
PART    3[    4]:  4b 49 4e 47
PART    4[    9]:  50 52 45 53 49 44 45 4e 54
PART    5[    0]:
PART    6[    7]:  77 b5 0b 11 01 01 01
PART    7[    2]:  c2 33
PART    8[    0]:
PART    9[ 1031]:  00 70 00 01 01 0c 00 80 00 01 00 00 00 01 00 00 00 0e a6 42 03 f3 48 90 03 ed 01 00 03 e8 01 47 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41 41
PART   10[    2]:  c1 0b

CHANGE #1 CON_ID:3 TYP:0 CLS:21 AFN:11 DBA:0x024000a0 OBJ:4294967295 SCN:0x000000000025b1cc SEQ:1 OP:5.2 ENC:0 RBL:0 FLG:0x004a
CHANGE #2 CON_ID:3 TYP:1 CLS:22 AFN:11 DBA:0x024011d8 OBJ:4294967295 SCN:0x000000000025b216 SEQ:1 OP:5.1 ENC:0 RBL:0 FLG:0x0c08
CHANGE #3 CON_ID:3 TYP:0 CLS:1 AFN:12 DBA:0x030000f4 OBJ:74462 SCN:0x000000000025b216 SEQ:1 OP:11.2 ENC:0 RBL:0 FLG:0x0000
```

LOBs - binary XML

- Uses Oracle's proprietary binary XML format https://www.oracle.com/technetwork/database-features/xmldb/oracle-binaryxml-rfc-128974.pdf
- To decode the binary XML bytes you will need to access the database package DBMS_CSX_ADMIN package (Ref.: https://odieweblog.wordpress.com/2016/08/27/inside-binary-xml/)
- Therefore, when a table containing our column with the XML data type has '`supplemental log data (ALL) columns`' set, a redo record containing OP:24.8 with the original XML is generated (together with all previously described additional OP:11.17)
- This negates the benefits of using binary XML. Details description and size comparison - https://averemee.substack.com/p/oracle-xmltype-in-redo-logs

LOBs - binary XML

```
REDO RECORD - Thread:1 RBA: 0x00000d.00043820.0064 LEN: 0x0200 VLD: 0x01 CON_UID: 786076231
SCN: 0x000000000027cb4e SUBSCN: 5
CHANGE #1 MEDIA RECOVERY MARKER CON_ID:3 SCN:0x0000000000000000 SEQ:0 OP:24.8 ENC:0 FLG:0x0000
XML redo opcode type: 1 xid:0x0002.020.00000351 obj:74494
internal column id: 8
XML data load
3c 3f 78 6d 6c 20 76 65 72 73 69 6f 6e 3d 22 31 2e 30 22 3f 3e 0a 20 20 20 20
20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 3c 50 4f 20 70 6f 6e 6f 3d 22
31 22 3e 0a 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
20 3c 50 4e 41 4d 45 3e 50 6f 5f 32 3c 2f 50 4e 41 4d 45 3e 0a 20 20 20 20 20
20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 3c 43 55 53 54 4e 41 4d
45 3e 4f 72 61 63 6c 65 3c 2f 43 55 53 54 4e 41 4d 45 3e 0a 20 20 20 20 20 20
20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 3c 53 48 49 50 41 44 44 52
3e 0a 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
20 20 3c 53 54 52 45 45 54 3e 35 30 30 2c 20 54 77 69 6e 20 44 6f 6c 70 68 69
6e 20 44 72 69 76 65 3c 2f 53 54 52 45 45 54 3e 0a 20 20 20 20 20 20 20 20 20
20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 3c 43 49 54 59 3e 42 65 6c
6d 6f 6e 74 3c 2f 43 49 54 59 3e 0a 20 20 20 20 20 20 20 20 20 20 20 20 20 20
20 20 20 20 20 20 20 20 3c 53 54 41 54 45 3e 43 41 3c 2f 53 54 41
54 45 3e 0a 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
20 3c 2f 53 48 49 50 41 44 44 52 3e 0a 20 20 20 20 20 20 20 20 20 20 20 20 20
20 20 20 20 20 20 20 3c 2f 50 4f 3e
Change # 1
PART   0[    1]:  01
PART   1[    4]:  00 00 00 00
PART   2[    8]:  02 00 20 00 51 03 00 00
PART   3[    4]:  fe 22 01 00
PART   4[    2]:  01 00
PART   5[    2]:  08 00
PART   6[    4]:  03 00 00 00
PART   7[  402]:  3c 3f 78 6d 6c 20 76 65 72 73 69 6f 6e 3d 22 31 2e 30 22 3f 3e 0a 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 3c 50
4f 20 70 6f 6e 6f 3d 22 31 22 3e 0a 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 3c 50 4e 41 4d 45 3e 50 6f 5f 32 3c 2f 50 4e
41 4d 45 3e 0a 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 3c 43 55 53 54 4e 41 4d 45 3e 4f 72 61 63 6c 65 3c 2f 43 55 53 54
4e 41 4d 45 3e 0a 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 3c 53 48 49 50 41 44 44 52 3e 0a 20 20 20 20 20 20 20 20 20
20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 3c 53 54 52 45 45 54 3e 35 30 30 2c 20 54 77 69 6e 20 44 6f 6c 70 68 69 6e 20 44 72 69 76 65 3c 2f 53
54 52 45 45 54 3e 0a 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 3c 43 49 54 59 3e 42 65 6c 6d 6f 6e 74 3c 2f 43 49
54 59 3e 0a 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 3c 53 54 41 54 45 3e 43 41 3c 2f 53 54 41 54 45 3e 0a 20 20
20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 3c 2f 53 48 49 50 41 44 44 52 3e 0a 20 20 20 20 20 20 20 20 20 20 20 20 20 20
20 20 20 3c 2f 50 4f 3e
```

The impact of supplemental logging: how to reduce it

Building logical replication on top of the originally designed physical data replication requires supplemental logging. If we need a CDC, we must turn supplemental logging on and we must be careful and understand the cost of this.

- Avoid LOBs, if possible
  - Instead of one entry, at least four are generated for LOBs with supplemental log data set. More for binary XML. The redo log is a bottleneck in the database I/O system. And therefore, it's worth reconsidering – is it really right to store LOBs (XMLTYPE, JSON, VECTOR) in the database? After all, there are [object] file systems for this.

The impact of supplemental logging: how to reduce it

Use database level minimal supplemental logging - reasonable overhead for plain data, i.e. non LOB data, with supplemental logging set. But - no selectivity…

- I hope that someday the '**SUBSET DATABASE REPLICATION**' will work as described.

Q&A